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XLII.—*Remarks on an Essay by Prof. G. Lindström, entitled "Contributions to the Actinology of the Atlantic Ocean," and a Reply to some of his Criticisms.* By Prof. P. MARTIN DUNCAN, F.R.S., V.P.G.S., &c.

IN 1876 Prof. Lindström communicated his essay * on the actinology of the Atlantic Ocean to the Royal Swedish Academy. It contained descriptions of corals which had been dredged up from off the Josephine Bank and the sea-floor near the Azores, Virgin Islands, Salt Island, and Anguilla. The depths varied from 109 to 980 fathoms.

After reading the essay carefully and comparing Prof. Lindström's statements with those of his predecessors in the same kind of research, I found that he differed from everybody in opinion, and often in matters of fact. I have hitherto carefully avoided disputation in scientific matters, and I felt no disposition to reply to Prof. Lindström, especially as I was aware how erroneous many of his statements were. I hoped that time would bring some remarks from him after M. de Pourtalès and Prof. H. N. Moseley, F.R.S., had contravened some of his assertions. But lately having been engaged in a

* Kongl. Svenska Vetenskaps-Akad. Handl. Bd. xiv. no. 6, published in 1877.

revision of the genera of corals, it was necessary for me to reconsider the essay on the actinology of the Atlantic.

Much has been written upon the deep-sea corals since Prof. Lindström's essay was read. Thus my paper on the Madreporaria dredged up by H.M.S. 'Porcupine' was read May 1876 and published in 1878 (Trans. Zool. Soc. vol. x. part 5, 1878).

Prof. H. N. Moseley's preliminary report on the 'Challenger' corals (1875) was followed in 1879 by the reception of his full report on the 'Challenger' corals. This book was published subsequently.

The late M. de Pourtalès published the Report on the Corals and Antipatharia of the 'Blake' Expedition in 1880.

These researches might have modified Prof. Lindström's views; but as they do not appear to have done so, it is necessary that I should criticize them seriatim, taking the opportunity, however, to point out the valuable parts of the Professor's communication.

1. Lindström makes the interesting discovery of the presence of the variety *borealis*, nobis, of *Caryophyllia clavus*, Scacchi, as far south as lat. $48^{\circ} 19'$, in 109 fathoms. Hitherto it had only been known as a North-Atlantic and Mediterranean form. He gave the first locality beyond its supposed home for this variety, which now has been found by Moseley in the Patagonian area.

2. I described *Caryophyllia Pourtalesi*, dredged from deep water in the North Atlantic*. Professor Lindström says:— "This coral cannot properly be classified with the genus *Caryophyllia*, as there are no regular paluli, and all such are entirely wanting in the North-Atlantic specimen (*i. e.* Lindström's). But my material is too scanty to decide the question." He places *Paracyathus thulensis*, Gosse, as a synonym.

My material was not scanty, and the species was minutely described and the small columella and the irregular pali were noticed. In an essay on the 'Porcupine' Madreporaria (part 2), which I read before the Zoological Society a few months after Prof. Lindström read his, I gave abundant evidence of the existence of pali in the species; and Erxleben's drawings clearly indicate them†. The number of pali is small, and they are especially visible when the columella is

* "Madreporaria dredged during the Expeditions of H.M.S. 'Porcupine,'" Trans. Zool. Soc. vol. viii. pt. 5, p. 317, pl. xlvi. figs. 3-10.

† Trans. Zool. Soc. vol. x. pt. 5, p. 238, pl. xlvi. figs. 1-7. Read May 1876, published 1878. Illustr. Cat. Mus. Comp. Zool. Harvard.—No. IV. "Deep-sea Corals," 1871, p. 12, pl. iii. figs. 1, 2, 3.

small. They are thin and long, and are placed before the third cycle when the fourth and fifth orders are complete. They follow the law, which certainly has a meaning and classificatory value, that pali do not exist in relation to incomplete septal cycles. There is nothing present which can confound my form with Gosse's *Paracyathus*; and therefore I hold that the species I established from a considerable number of specimens, and which was considered doubtful by Lindström after the examination of one coral (which probably was not of the species at all), is a true member of the *Caryophyllia* group, and should retain the name I gave it.

3. *Leptocyathus Stimpsoni*, Pourtalès.—This coral, so interesting from its being associated with a fossil genus, was described by Pourtalès in 1871; he had some doubt about the denticulate septa taking the form out of the Turbinolidæ, but he was sure upon the point of the existence of pali (paluli), although those of the higher orders were not very distinguishable from the columellar processes. Lindström states, "There are no paluli, and the papillæ which compose the columella may sometimes be mistaken for paluli. The species, as well as the following (*Leptocyathus?* *halianthus*, Lindst.), cannot be classed with the *Leptocyathi* in the sense of Milne-Edwards and Haime."

This criticism was answered by Pourtalès in the Report on the 'Blake' Corals*. He wrote, "Mr. Lindström doubts the propriety of referring these corals to the genus *Leptocyathus*, although he adopts the genus provisionally. He did not recognize the pali, which, however, I find quite distinct in large specimens in front of the tertiaries; but I have had no opportunity of direct comparison with the fossil species." Prof. Lindström is wrong, as he might have expected he would be found to be, for Pourtalès was a most careful observer. I have two small specimens, one of which certainly is Pourtalès's type, for he sent it to me named. It has pali easily recognizable and before all the septa, except those of the last order. The beautiful type of the genus from the London Clay † and the equally elegant form described from the Gault ‡ have pali before all the septa, and the principal costæ are produced so as to give an appearance like Moseley's discoid *Stephanotrochus* §.

Pourtalès's species comes into relation with an Eocene form

* Bull. Mus. Comp. Zool. Harvard, no. 9, ii. p. 201.

† Palæont. Soc. Lond., Brit. Foss. Corals, 1850, p. 21.

‡ Palæont. Soc. Lond., Brit. Foss. Corals, Supplement, pt. ii. no. 2, p. 34 (1870).

§ Report on 'Challenger' Corals, pl. iii. fig. 5.

from Sind (*Leptocyathus epithecata* *), and with the discoid *Trochocyathi* from the Cainozoic of Australia †.

Lindström describes "*Leptocyathus? halianthus*" (*op. cit.* p. 9, pl. i. fig. 9), and states that "this species is only provisionally to be ranged in the genus *Leptocyathus*, as there seems to be a great discrepancy in the arrangement of the secondary and tertiary septa, which do not unite in the previously known species." The form is largely fixed, with a broad basis; the costæ are warty and spinulose. The septa in six cycles, each containing primaries, secondaries, tertiaries, and septa of the fourth and fifth orders. Lindström states that the tertiaries are united at their "base" with the septa of the second order, and, again, those of the fourth and fifth orders are united with those of the third. But in the very clear drawing the septa of the fourth and fifth orders are straight, and do not unite with those of the third order. Which is correct, the drawing or the description? One must be wrong. The tertiary septa do unite with the secondary.

Prof. Lindström is quite correct in remarking that union of the tertiary and secondary septa has not been noticed in the previously described species. In the Tertiary species of England and Sind and in the species from the Gault there is no such union. But it is hardly a generic character. The only distinction between *Leptocyathus*, Edw. & H., and discoid *Trochocyathi* is the presence of pali before the higher orders in the first-named. This can no longer be admitted to be of generic value, and the genus must be absorbed in *Trochocyathus*.

What is the classificatory position of this doubtful form described by Lindström? Either there are pali or there are none; and the describer states that the slender styliform angular papillæ of the columella encroaching on the basis of the septa form, as it were, a semblance of paluli (pali). The basis means, according to Lindström, the axial end of the septum.

Admitting that there are no pali, the calice strongly resembles that of *Sabinotrochus apertus*, nobis ‡; and if the larger septa had been prolonged, the identity of the forms could hardly be doubted so far as the calice is concerned. Unfortunately Lindström does not say any thing about the number and arrangement of the costæ. If there are pali, the species must come within the genus *Trochocyathus*.

* Palæont. Indica, ser. xiv., Foss. Corals of Sind, p. 60 (1880).

† Quart. Journ. Geol. Soc. vol. xxvi. p. 296 (1870).

‡ Duncan, "Deep-sea Corals," Trans. Zool. Soc. vol. viii. pt. 5, p. 320, pl. xli.

4. *Deltocyathus Agassizi*, Pourtalès.—Lindström retains the modern name for this species, which has been exhaustively examined by Pourtalès and Moseley, and to the consideration of which I have given some care. Pourtalès sent me a specimen, and I recognized it as the well-known species *Deltocyathus italicus*, Michelotti sp., of the Tortona and other Italian Miocene deposits. Since then Pourtalès has acknowledged the fact*, and Moseley gives the proper name to the species in his "Report on the 'Challenger' Corals," p. 145, in which he quotes the final decision of the lamented naturalist. It is a most variable species, and has a wide geographical distribution.

Lindström considers some East-Atlantic specimens which have small paluli, an attached base, and thin walls to bring *Sabinotrochus apertus*, Duncan, within the species *Deltocyathus Agassizi*. Moseley spared me the trouble of answering this most extraordinary conclusion †:—"After comparing Prof. Martin Duncan's specimen of *Sabinotrochus apertus* with the series of *Deltocyathus*, I conclude that Prof. Lindström's conjecture that it is a variety of *Deltocyathus Agassizi* cannot be upheld. *Sabinotrochus* differs in its general texture and in the thickness of its septa, in its fine wavy costæ, and in the margin of the calicle being indented, also in the complete absence of pali, which are certainly not broken away."

Sabinotrochus and *Deltocyathus* are two perfectly distinct genera, and do not belong to the same group, even of the Turbinolidæ. Certainly Prof. Lindström's critical method is the reverse of complimentary, and we do not want conjectures.

Next Prof. Lindström considers that a form described by Pourtalès (*Trochocyathus Rawsoni*) "may perhaps also belong to this species (*Deltocyathus Agassizi*=*D. italicus*), being provided with septa and columella of the same shape" (p. 10). Pourtalès photographed the type of his species in pl. vi. figs. 7-10, of "Zoological Results of 'Haslar' Expedition" ‡. Certainly the costæ and pali of *Trochocyathus Rawsoni* remove it entirely from *Deltocyathus*. It is a true *Trochocyathus*, allied to all forms with the tertiaries uniting to the secondaries. After seeing Lindström's criticism, Pourtalès still retained the form in the genus *Trochocyathus*, and considered that it was not without its affinities with *Paracyathus*.

Lindström compensates, however, for his unfortunate zoolo-

* "Report on 'Blake' Dredging Expedition," Corals, by Pourtalès, 1878-79, p. 101.

† Moseley, *op. cit.* p. 146.

‡ Ill. Cat. Mus. Comp. Zool. Harvard, no. 8 (1874).

gical criticisms by giving the following interesting result of his examination of young specimens of *Deltocyathus italicus* * :—“ In the smallest specimen I have seen, of only 0·7 millim., there are four septa of the first order, towards which two of the second order are growing, and with these again the smaller belonging to the third order unite. But to judge by a specimen which is a little bigger (1·5 millim.) and has six regular septa of the first order, the law of substitution as expressed by Lacaze-Duthiers (Arch. de Zool. Expér. t. i. p. 368) comes into play; and of the six apparently primary septa four may have been developed out of secondary ones, only two of the original four resting in their original position as septa of the first order, the other two being, as it were, pushed aside and degraded into secondary ones.” Nevertheless it must not be imagined that this arrangement is universal in the genus, for in the specimens in my possession the regularity of the appearance of six primaries and the succession of six secondaries is clear, and it is confirmed by the study of the costæ. The term “ phenomenon of substitution ” is much more correct than the term “ law.”

5. *Flabellum laciniatum*, Philippi, sp.—Lindström recognizes amongst the Josephine dredgings the common North-Atlantic *Flabellum*, which Sars had called *Uloctyathus arcticus*. But he confounds with it *Flabellum alabastrum*, Moseley—a conclusion which is refuted by that author in his “ Report on the ‘Challenger’ Corals,” with which I agree.

6. *Duncania barbadensis*, Pourtales.—Lindström makes some valuable remarks upon this species, and notices the sameness of the septa, except those which are in relation to pali. He states that the material which fills up the calice from its base is stereoplasma, or a secretion of the basal membrane superseding or supplementing the dissepiment. He gives the only comprehensible drawing of the calice we have, and states that he has found six septa near the base. I found in a *Gwynia* a tetrameral arrangement of septa above, but a hexameral one at the base.

Pourtales states that *Haplophyllia*, which comes close to *Duncania*, has the soft parts similar to this last. At present these genera, I consider, must be associated with *Gwynia*, nobis, in a group in the Turbinolidae, and not with the Rugosa.

7. *Schizocyathus fissilis*, Pourtales.—Lindström obtained the specimens he described from Anguilla, Salt Island, and the Josephine Bank, in from 200 to 790 fathoms. He describes an epitheca, which is not to be distinguished from

* *Op. cit.* p. 11.

the wall, and Pourtalès distinctly denies the existence of an epitheca. Lindström's drawing of a calice does not correspond in a very important character with the photograph of Pourtalès. There are no septa in Lindström's figure (pl. ii. fig. 27) in the position of the primaries of Pourtalès, and what are marked primaries by Lindström are the secondaries of Pourtalès. Lindström, however, states that there are six primaries, twelve secondaries, and six tertiaries. The coral is most carefully described by our author, and the discrepancies are perfectly incomprehensible and inexplicable. Nothing can be more interesting to zoophytologists than Lindström's remarks on the stereoplasma of this coral, on the prolongation of the ornamental granules to form false synapticula, and on the nature of the septum.

Lindström combats the teaching of Milne-Edwards and Jules Haime that each septum consists of two laminæ. He believes that the dark irregular central line seen in sections is the primary condition, and that the thick calcareous substance on either side is superadded—that really three and not two structural elements exist. He candidly admits that the two laminæ are to be seen in some fossils. They are visible enough in many recent forms; and in some Australian fossil forms where the costa does not correspond with the septal end, and this is continuous with the intercostal median line, the line which separates the septal laminæ is singularly distinct. In investigating this matter I find that the centre of the recent septum has more connective tissue than the laminæ on either side; and this can be well made out by treatment with acid—the ultimate microscopical structures radiate often from the central plane. That Lindström is right about the central line being anterior to the rest is beyond a doubt, but I do not find that it was a lamina for all that.

The splitting of the parent by an internal bud, noticed probably in the first instance by Savile Kent in a *Flabellum*, does not appear to be the phenomenon observed in *Schizocyathus* according to Lindström. He points out that "it is not a gemmation, but an interrupted and then continued growth of the same individual." He instances similar processes of growth in *Flabellum laciniatum* and *Diaseris crispa*. Now Pourtalès states that the budding takes place on the secondary septa in the calice; and it must be confessed that although Lindström's figure (pl. iii. fig. 29) looks like what has recently been called rejuvenescence, and has been known for a generation as growth after arrest, the appearance of figs. 28, 30, and 31 favours the opinion of Pourtalès.

8. *Stenocyathus vermiformis*, Pourt.—Lindström and Pourtalès differ so much in their description of the appearance and morphology of this coral that it is hardly conceivable that they are treating of the same species. The species was described and delineated by Pourtalès in his 'Deep-sea Corals' (1871, p. 10, pls. i. & iii.). It is a very elongated and cylindrical form, with a shallow circular calice, septa not exsert, rather thick, and in six systems of three cycles. Pali thick, curled, and in front of the secondary septa. Columella of a single twisted process. Costae indicated by lines of very flat tubercles. The older parts of the corallum are nearly filled up by a thickening of the septa; but the process is never carried out to a total obliteration of the interseptal chambers, which can be traced in the shape of slender canals to the very base. The costal tubercles are hollow and communicate through narrow canals with the interseptal chambers. Pourtalès considered that "these little cavities are, no doubt, homologous with hollow roots of *Rhizotrochus*, *Thecoccyathus*, and other genera of the family." The height of the type was from 25 to 40 millim. and the diameter only 2 or 3 millim.

In the generic diagnosis it is stated that there is no epitheca.

The corals considered to belong to this species by Prof. Lindström never assume the vermiform shape!!! and are of a regular turbinate growth. In fact the diameter of the calice is one half of the length of the corallum. There are no tubercles as described by Pourtalès, and the dots "can in no way be considered as homologous to the rootlets in *Rhizotrochus*, *Thecoccyathus*, and several other corals." In Prof. Lindström's corals there is a dense network of dissepiments which are developed out of the spines or tubercles on the lateral surfaces of the septa.

In the description of the corals dredged in the 'Blake' expedition Pourtalès contents himself with remarking:—"I cannot find in my specimens the dissepiments mentioned by Mr. Lindström."

Pourtalès gave me a specimen of this curious species, which tallies with his description, and not in the least with Prof. Lindström's. It is only necessary to remark that the so-called dissepiments are not what are usually called such, and that they certainly are not synapticula, which are structures independent of ornamentation.

Probably Prof. Lindström's very hasty criticism was bestowed upon a totally different species from that recognized as *Stenocyathus vermiformis*, Pourt.

It must be observed that there is an epitheca in every specimen.

9. *Calcosmilia fecunda*, Pourt.—This coral gave Pourtalès

much trouble, and he illustrated it several times, and stated that the edges of the septa send out trabecules, uniting together to form a rudimentary columella, which is, however, frequently absent (1871). In 1874 the same author described a new genus *Cænosmilia*, and noticed it as a genus formed to receive the *Parasmiliae* propagating by gemmation, and thus becoming compound. Single corals are typical *Parasmiliae* with a well-developed spongy columella.

Prof. Lindström does good service in explaining that the gemmation in both these instances is not from within, but that buds have attached themselves accidentally to the surface of the old form; and in the 'Blake' corals Pourtalès (p. 109) states that his alcoholic specimens show that the young one is upon a dead old one. These are therefore clearly not budding corals in the proper sense.

10. *Paracyathus arcuatus*, Lindst.—This species Pourtalès has shown to belong to the genus *Asterosmilia*, nobis, and to be the species *Asterosmilia prolifera*, Pourt. ('Blake' Corals, p. 109).

Conclusion.

1. *Caryophyllia Pourtalesi*, nobis, belongs to the *Caryophyliae*, and is a good species.

2. *Leptocyathus Stimpsoni*, Pourtalès, was perfectly drawn and described by Pourtalès, who noted the pali which Lindström missed. But neither the species nor my *Leptocyathus endothecata* of Sind can remain in the genus, which is worthless: they are discoid *Trochocyathi*. Prof. Lindström's *Leptocyathus?* is of doubtful position.

3. *Deltocyathus italicus* is the correct name for *D. Agassizi* according to Pourtalès and myself. *Sabinotrochus apertus*, nobis, is, according to Moseley, a correctly named species, and is altogether different from a *Deltocyathus* seen by Prof. Lindström. *Trochocyathus Rawsoni*, Pourtalès, is correctly placed, and Prof. Lindström is in error.

4. As Moseley has already pointed out, Prof. Lindström is wrong in confounding *Flabellum alabastrum*, Moseley, with *Flabellum laciniatum*.

5. *Haplophyllia*, *Duncania*, and *Gwynia* must be removed from the Rugosa.

6. The descriptions of Pourtalès and Lindström regarding *Schizocyathus fissilis* are not reconcilable.

7. *Stenocyathus vermiformis*, Pourtalès, has not the structures recognized by Lindström.

8. Lindström's observations on the budding of *Calosmilia secunda*, Pourt., are very good and useful.

9. *Paracyathus arcuatus*, Lindst., is *Asterosmilia prolifera*, Pourtalès.